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(54) A NON-CONTACT WEB TENSION METER.

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Description

The invention relates to a web tension meter of the general kind set forth in the preamble of Claim 1 (US—A—2945637 or SE—C—207513).

The non-contact measurement of moving web is known in the art and has been employed, for example, for regulating tension when winding paper onto reels and unwinding paper therefrom. Examples of this methodology are found in U.S. Patent Specification No. 2,945,637. In accordance herewith, the web is drawn in a curved path over a perforated curved plate through the holes of which air is blown so as to produce a kind of air-cushion bearing between the plate and the paper. The greater the tension in the paper, the less air consumed, so that the air pressure increases inwardly of the perforated plate. A similar arrangement is known from the Swedish Patent Specification No. 207 513, although in this case the pressure is measured via one or more measuring apertures located in the wall in which the air-exhaust orifices are seated. It is possible herewith to measure the web tension at a number of positions across the width of the web.

These known non-contact web-tension measuring apparatus, however, have the disadvantage that it is necessary to change the direction of the web, by drawing the same over a plate or like element, admittedly while supporting the same on an air cushion and therewith in a manner which is at least contactless in principle, but not reliably so in practice. Although, as far as the arrangement disclosed in the aforesaid Swedish Patent Specification is concerned, it is possible to measure web tension at mutually different locations across the width of the web, these measurements can only be taken at fixed locations determined by the construction.

It is an object of the invention to provide a non-contact web tension meter which can be placed against a web without needing to change the direction of the web and the position of which, moreover, can be freely moved to any part of the web whatsoever across the breadth of the web, and which is therewith suitable for incorporation in a transversable measuring head, for co-action with other measuring devices operative in measuring thickness, moisture content and other variables of interest with regard to process controls and quality controls. The measuring process shall preferably provide a linear, or near linear, result.

In order to elucidate this object, it may be mentioned that during my work with thickness gauges for measuring the thickness of moving paper webs, I discovered through experiment that the thickness of a paper web, at least when measured in a contactless manner or with but low surface pressure, surprisingly changes when a change in web tension occurs. One might presume that an increase in tension would result in a thinner paper, due to transverse contraction. What was found during experimentation, however, was something far more complicated, a matter which moreover, is contingent on the kind of thickness gauge or meter used. When a non-contact meter of the kind disclosed in Swedish Lay-Open Print 434 997 is used, stretching of the web will initially result, in the case of newsprint, in the measured thickness increasing by 3—4 micron (force 0—0.2 N/m) and then increasing more gradually by some further microns (force 0.2—1.0 N/m) and only then, when this point is reached, decreasing when tension is increased. Although I cannot be sure, I assume that this effect is due to the "pile" of the paper rising as the paper is placed under tension. Consequently, in order to obtain a true value in respect of the thickness of the paper, it is necessary to know the tension therein, in order to make a suitable correction. Newsprint can have a standard thickness of 80 micron and it is desirable to be able to maintain control of this thickness to within about one or two micron, or better. In addition, it should be noted that contacting thickness meters have an even greater dependency on web tension than do present day non-contacting thickness meters.

Measurements of the web tension, correlated with other measurements is desirable in continuous manufacture control processes, for controlling a paper machine. This control is normally effected by heating a roller located in the machine to varying degrees of temperature at different locations along the length of the roller, to achieve a uniform thickness. A web of uniform thickness is a requirement from the printers. Data relating to the web tension is also important when the paper is to be wound on reels, and there is reason to suspect that irregularities in the tension of the wound web are the cause in many cases of unforeseen web fractures when, for example, printing newsprint. A paper roll which has been wound properly with respect to web tension is also less likely to become non-round.

The aforementioned objects and advantages are achieved in accordance with the invention by means of a non-contact web tension meter having the characterizing features set forth in Claim 1.

The meter is suitably of a telescopic construction controlled by pressurized gas, such as to be withdrawn when pressure gas falls away. This is achieved with an embodiment according to Claim 2. A preferred embodiment in this respect is set forth in Claim 3, in which embodiment the meter can only be extended telescopically when the pressure exceeds a given minimum pressure. A further improvement in this respect, and an improved function during a measuring operation, is obtained with an embodiment according to Claim 4 or Claim 5. The width of the pressure aperture should be small in relation to the width of the web and preferably not greater than one twentieth thereof, and it is suitable to permit solely the lips which define the pressure aperture and the measuring aperture, to face towards the web.

The invention will now be described with reference to an embodiment thereof illustrated in the accompanying drawing.

Fig. 1 is a side view of a web tension meter.

Fig. 2 illustrates the same web tension meter in cross-section.

Fig. 3 illustrates a stationary testing station.

Fig. 4 illustrates a test result obtained in the testing station shown in Fig. 3.

Fig. 5 illustrates variations in thickness with web tension in respect of two mutually different papers.

Fig. 6 illustrates the effect of a correction made to a paper profile without taking web tension into account.

Fig. 1 is a schematic side view of a web tension meter according to the invention. Seated in a holder 3 is a measuring head, which is substantially of cylindrical shape and has a diameter of 30 mm. A pressurized air-inlet is shown at 4, and a pipe 5 is connectable to a pressure meter. Such pressure meters are known to the art in many variations. In the illustrated embodiment there has been used a low pressure transducer designated Mod. 261 from Setra Systems, 45 Nagok Park, Acton, Mass. USA. As clearly shown in Fig. 2, the measuring head is divided into two parts, a stationary part 1 and a movable part 2, these parts moving telescopically relative to one another. The stationary, upper part is hollow and has a narrow opening 14 and a wider opening 16 and a cap 18, through which the pressurized-air pipe 4 extends. The movable part comprises a nozzle part which is firmly mounted on a stem 15 fitting in the opening 14 and the other end of which carries a piston 13 which fits in the wider opening 16. A compression spring 12 is mounted so as to tend to draw the stem 15 inwardly to the position shown in Fig. 2. An air passage 11 extends through the stem, up to the nozzle part and is terminated in one direction in a sealing ring 17, which is located on the upper side of the piston and which, in the illustrated position, seals against the inner surface of the cap 18, around the air inlet hole 4.

It will be seen that the piston 13 when occupying the illustrated position will not be affected by the pressurized air introduced until there is reached a pressure of such magnitude as to free the sealing ring 17 from the cap 18, against the action of the spring 12.

The passage 11 opens into the outwardly open space 8, via a coarse sintered plate 19. The sintered plate contributes in holding up the pressure in the passage 11, so that sufficient pressure is obtained through the supply of pressurized air for pressure to be exerted over the whole of the upper surface of the piston 13, whereafter the piston forces the movable part 2 out to a working position, not shown.

When using the meter to measure the tension in a web, the web is brought into position for abutment and, in use, is spaced at a distance of approximately 1 mm from the lower portion of the movable part 2 and forms a defining wall of the space 8. Extending around the space 8 is an annular chamber 7 with an annular measuring slot 9, outwardly defined by a lip 10. When the space 8 is pressurized to a pressure of 0.5—1 bar, the yielding web will move away to a greater or lesser extent, depending upon the tension prevailing in the web. The pressure measured in the pressure gauge connected to the measuring slot 9 through the passage 5 will vary with web tension. The measuring result, on the other hand, is not particularly influenced by the pressure of the input air, and hence quite primitive pressure control devices will suffice.

It might be possible to guess beforehand that such a dependency is to be expected, by relatively elementary considerations. However, the fact that this effect is found to be linearly or nearly linearly, dependent on the web tension, rendering the invention well suited for the aforesaid measuring function, is likely to surprise one of normal skill in this art.

It has been possible to ascertain this linearity experimentally. In one experiment a strip of paper 30 (type newsprint) having a length of 2 m and a width of 440 mm was hung vertically between two supports 31 and 32, and was loaded with a container 33, into which water could be poured. With the container empty, the tension corresponded to a load of 220 grams. A web tension meter 34 was placed against the surface of the paper. The geometry will be seen from Fig. 3, in which the measurements are in millimeters. The result obtained with this arrangement is shown in Fig. 4, where the values in percentage of a full-scale reading on the pressure meter used are plotted on the X-axis. The curve obtained was practically linear.

It will be understood that the force conditions are not completely simple, since the arrangement functions with a flowing gas. It will be perceived that there prevails in the space 8 (Fig. 2) a static pressure which, quite naturally, will force the paper outwardly, away from the measuring head. The air, however, also flows, at the same time, laterally in the gap formed between the head and the paper web, creating a vacuum force in accordance with Bernoulli's law, which strives to draw the paper towards the head. The measured pressure is influenced by this sub-pressure. That the result of these different effects brings about a result which is a linear, or near linear function of the web tension, is apt to cause surprise, as is also the fact that the measuring result depends so little on the applied pressure, within wide limits.

Tests have also been carried out with moving webs, with paper wound from one roll to another. As far as could be seen, the measuring result is not influenced by the speed at which the web moves. In this arrangement the web forms at a location opposite the head a little pronounched "valley", having a length in the feed direction of some twenty centimeters and a width which slightly exceeds the width of the head.

In order to illustrate the particular problem within the paper industry where the invention affords a solution, reference is made to Fig. 5, which shows the change in paper thickness in microns as a function of web tension. The curves

51 and 52 show the results obtained with tests carried out on news print obtained from two different Swedish paper mills. The difference is not one of chance; on the contrary, paper samples obtained from the two mills consistently exhibiting each its particular curve form. It will be seen that when stretching, there is a rapid increase in thickness succeeded by a more gradual increase in thickness with a further increase in the tension, finally followed by a decrease in thickness for web tensions above 1 N/m. It is apparent that no accurate measurement of the thickness of paper webs is possible when they are tensioned, unless the effect of the web tension is corrected for.

Fig. 6 illustrates the effect of a thickness measurement which is impaired by errors due to failing to compensate for web tension. Fig. 6 shows along the X-axis the width of a paper web which is assumed to be initially of uniform thickness, i.e. does not deviate from a desired standard thickness. This standard uniform thickness is shown by the line 61. A variation in web tension exists, however, across the width of the web, shown by the broken line curve 62, which is quite representative, since web tension is often lower at the edges of the web. If the thickness of the web is now measured, the value obtained will be in error, the paper being found thicker in the centre of the web. When correcting this supposed error until a uniform thickness is found in the thickness meter, there will actually be obtained a manufactured paper having a true thickness curve which exhibits the deviation shown by the chain line 63.

As to the accuracy aspect of thickness measurements, the following can be said. Standard newsprint has a thickness of roughly 80 micron. Newsprint which exhibits variations in thickness in the order of 10 micron is considered to be second-rate, and a standard manufacturing tolerance is at present 2 micron. Variations in thickness are significant both with respect to the quality of the print obtained and to the risk of web fracture. High accuracy measurement of web thickness during manufacture would be highly beneficial in producing a uniform dry weight of the paper across the whole of its breadth. At present, it is necessary, instead, to make corrections by drying the web to varying degrees at different locations across the width, so as in this way to reduce the variations in thickness when calendering the formed paper. The varying magnitudes of moisture content of the finished paper rolls are economically disadvantageous to the paper mill, which by applying better controls—solely possible by improved thickness measurement—could reduce the consumption of raw materials for each ton of paper produced without loss of quality. Winding of newsprint into rolls (diameter 2 m) can also be controlled in an improved manner, and a suitable tension distribution obtained, all by accurate measuring of the tension of the web. There is a well-founded general suspicion that a poor lateral distribution of the web tension profile is an essential source of web fracture in printing shops.

Claims

1. A non-contact web tension meter for measuring the tension of a web of material drawn under tension between two guide means, said meter incorporating means for supplying a pressurized gas to a space therein which is open in one direction and which is intended to be delimited by one side of the material web placed in the near proximity of said space, and a pressure gauge adapted to measure the gas pressure near the web at the side of said space, characterized in that it includes a holder (3) having affixed thereto a measuring head (1, 2) which incorporates a pressurized-gas inlet (4) having connected thereto a gas passage (11) which extends to said space (8), and an annular chamber (7) which surrounds said space (8) and which has an annular opening (9), the space (8) and the opening (9) terminating adjacent an end plane in the measuring head, and the annular chamber being connected to a pressure sensor.

2. A non-contact web tension meter according to Claim 1, characterized in that the measuring head has two parts, which are telescopically movable in relation to one another, of which a first part (1) is fixed to the holder (3) and carries the pressurized-gas inlet (4), and the second part (2) presenting the open space (8), which is intended to be placed under pressure, and the annular chamber (7), the said parts functioning as a piston and a cylinder respectively for moving the same mutually apart, against the action of a spring (12), upon introduction of the pressurized gas.

3. A non-contact web tension meter according to Claim 1, characterized in that mounted on the end of the second part (2) remote from the said end plane of the measuring head is provided with a stem (15) through which the gas passage (11) is drawn and which terminates with a piston (13) whose diameter is greater than that of the stem; and in that the first part (1) is provided with a first, elongated opening (14) for accommodating said stem, and a second opening (16) which is located in the extension of the stem (15) and adapted to accommodate the piston (13), the spring (12) being a compression spring arranged in the second opening between the piston (13) and the first opening (14), and the passage (11) being terminated at the end of the piston (13) opposite the spring (12) with an annular seal (17) adapted to lie in sealing abutment with the pressurized-gas inlet (4), the exit orifice of which is located in a wall (18) definingpthe second opening.

4. A non-contact web tension meter according to Claim 3, characterized in that a throttling plate (19) is arranged between the passage (11) and the space (8) intended to be placed under pressure.

5. A non-contact web tension meter according to Claim 4, characterized in that the throttling plate (19) is a sintered plate.

6. A non-contact web tension meter according to Claim 1, characterized in that the opening of the space (18) intended to be placed under pressure is arranged to take-up less than one twentieth of the

width of the web to be measured, and is defined by a first lip (6) towards the annular opening (9), which in turn is defined outwardly by a further lip (10), these lips thus together defining the annular opening (9), that side of the measuring head (2) facing the web solely comprising the surface formed by said two lips.

Patentansprüche

1. Berührungsfreies Bahnspannungsmeßgerät zur Messung der Spannung einer Materialbahn, die zwischen zwei Führungseinrichtungen unter Spannung steht, wobei das Meßgerät umfaßt Einrichtungen zur Einbringung eines Druckgases in einen darin befindlichen Raum, der in einer Richtung offen ist und der dazu bestimmt ist, abgegrenzt zu sein durch eine Seite der Materialbahn, die in unmittelbarer Nähe des Raumes angeordnet ist, und einen Druckmesser, der zur Messung des Gasdruckes nahe der Bahnseite, die dem besagten Raum zugewandt ist, vorgesehen ist, gekennzeichnet durch einen Halter (3), der einen Meßkopf (1, 2) hält, mit einem Druckgas-Einlaß (4), der mit einem, sich in den Raum (8) erstreckenden, Gasdurchgang (11) verbunden ist, und einer ringförmigen Kammer (7), die den Raum (8) umgibt und die eine ringförmige Öffnung (9) aufweist, wobei der Raum (8) und die ringförmige Öffnung (9) in Nachbarschaft zueinander in einer End-Ebene des Meßkopfes endet, und die Ringkammer (7) mit einem Drucksensor verbunden ist.

2. Berührungsfreies Bahnspannungsmeßgerät nach Anspruch 1, dadurch gekennzeichnet, daß der Meßkopf zwei Teile aufweist, die teleskopartig in Relation zueinander bewegbar sind, von dem ein erster Teil (1) fest mit dem Halter (3) verbunden ist und den Druckgas-Einlaß (4) trägt, und von dem ein zweiter Teil (2) den offenen Raum (8), der dazu bestimmt ist, unter Druck zu stehen, und die ringförmige Kammer (7) aufweist, wobei beide Teile sich als Kolben bzw. Zylinder getrennt voneinander gemeinsam gegen die Wirkung einer Feder (12) nach Einführung des Druckgases bewegen.

3. Berührungsfreies Bahnspannungsmeßgerät nach Anspruch 1, dadurch gekennzeichnet, daß das Ende des zweiten Teils (2), das der End-Ebene des Meßkopfes gegenüberliegt, mit einem Stempel (15) versehen ist, durch den der Gasdurchgang (11) geht und der mit dem Kolben (13) verbunden ist, dessen Durchmesser größer als der Stempel (15) ist, und daß der erste Teil (1) mit einer ersten verlängerten Öffnung (14) zur Aufnahme des Stempels (15) und einer zweiten Öffnung (12) versehen ist, die in der Verlängerung des Stempels (15) angeordnet ist und die der Aufnahme des Kolbens (13) dient, und daß die Feder (12) eine Druckfeder ist, die in der zweiten Öffnung (16) zwischen dem Kolben (13) und der ersten Öffnung (14) angeordnet ist, und daß der Durchgang (11) an dem der Feder (12) gegenüberliegenden Ende des Kolbens (13) mit einer ringförmigen Dichtung (17) endet, die so angeordnet ist, daß sie den Druckgas-Einlaß (4) abdichtet, dessen Ausgangsöffnung in der Wandung (18) angeordnet ist, die die zweite Öffnung (16) verschließt.

4. Berührungsfreies Bahnspannungsmeßgerät gemäß Anspruch 3, dadurch gekennzeichnet, daß eine Drosselplatte (19) zwischen dem Durchgang (11) und dem Raum (8), der dazu bestimmt ist, unter Druck zu stehen, angeordnet ist.

5. Berührungsfreies Bahnspannungsmeßgerät gemäß Anspruch 4, dadurch gekennzeichnet, daß die Drosselplatte (19) eine Sinterplatte ist.

6. Berührungsfreies Bahnspannungsmeßgerät nach Anspruch 1, dadurch gekennzeichnet, daß die Öffnung (8), die dazu bestimmt ist, unter Druck zu stehen, so angeordnet ist, daß sie weniger als 1/20 der Breite der zu messenden Bahn einnimmt und begrenzt ist durch einen ersten Rand (6) zur der ringförmigen Öffnung (9) hin, die wiederum durch einen weiteren Rand (10) nach außen hin begrenzt ist, so daß diese Ränder zusammen die ringförmige Öffnung (9) begrenzen und die Seite des Meßkopfes (2), die der Bahn zugewandt ist, allein aus der Oberfläche besteht, die durch die beiden Ränder gebildet ist.

Revendications

1. Tensiomètre de bande sans contact pour la mesure de la tension d'une bande de matière tirée sous tension entre deux moyens de guidage, ledit tensiomètre comportant un moyen propre à amener un gaz sous pression à un espace intérieur qu'il présente, ouvert dans une direction et destiné à être délimité par une face de la bande de matière placée à proximité immédiate dudit espace, et un manomètre propre à mesurer la pression de gaz régnant près de la bande sur le côté dudit espace, caractérisé en ce qu'il comporte un support (3) auquel est fixée une tête de mesure (1, 2) qui présente une entrée de gaz sous pression (4) à laquelle est relié un passage de gaz (11) qui s'étend jusqu'audit espace (8), et une chambre annulaire (7) qui entoure ledit espace (8) et qui présente une ouverture annulaire (9), l'espace (8) et l'ouverture (9) se terminant près d'un plan d'extrémité situé dans la tête de mesure, et la chambre annulaire étant reliée à un capteur de pression.

2. Tensiomètre de bande sans contact selon la revendication 1, caractérisé en ce que la tête de mesure comporte deux pièces, mobiles de manière télescopique l'une par rapport à l'autre, et dont une première (1) est fixée au support (3) et porte l'entrée de gaz sous pression (4), et la seconde (2) présente l'espace ouvert (8), destiné à être mis sous pression, et la chambre annulaire (7), lesdites pièces fonctionnant à la manière d'un piston et d'un cylindre respectivement pour s'écarter l'une de l'autre, à l'encontre d'un ressort (12), lors de l'introduction du gaz sous pression.

3. Tensiomètre de bande sans contact selon la revendication 1, caractérisé en ce que sur l'extrémité de la seconde pièce (2) distante dudit plan d'extrémité de la tête de mesure est montée une

tige (15) à travers laquelle est ménagé le passage de gaz (11) et qui se termine par un piston (13) de diamètre supérieur à celui de la tige; et en ce que la première pièce (1) présente une première ouverture oblongue (14) de réception de ladite tige, et une seconde ouverture (16) qui est située dans le prolongement de la tige (15) et propre à recevoir le piston (13), le ressort (12) étant un ressort de compression disposé dans la seconde ouverture entre le piston (13) et la première ouverture (14), et le passage (11) se terminant à l'extrémité du piston (13) opposée au ressort (12) avec présence d'un joint d'étanchéité annulaire (17) propre à buter de manière étanche contre l'entrée de gaz sous pression (4), dont l'orifice de sortie est situé dans une paroi (18) délimitant la seconde ouverture.

4. Tensiomètre de bande sans contact selon la revendication 3, caractérisé en ce qu'une plaque d'étranglement (19) est disposée entre le passage (11) et l'espace (8) destiné à être mis sous pression.

5. Tensiomètre de bande sans contact selon la revendication 4, caractérisé en ce que la plaque d'étranglement (19) est une plaque frittée.

6. Tensiomètre de bande sans contact selon la revendication 1, caractérisé en ce que l'ouverture de l'espace (8) destiné à être mis sous pression est agencée pour occuper moins d'un vingtième de la largeur de la bande soumise à la mesure et est délimitée par un premier rebord (6) en direction de l'ouverture annulaire (9), elle-même délimitée extérieurement par un autre rebord (10), ces rebords délimitant ainsi conjointement l'ouverture annulaire (9), le côté de la tête de mesure (2) orienté vers la bande étant seulement constitué par la surface occupée par ces deux rebords.

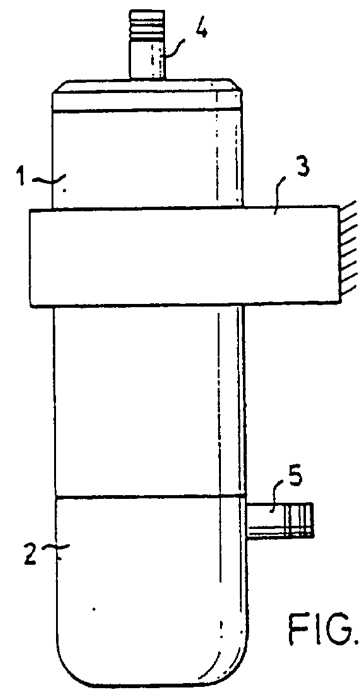


FIG. 1

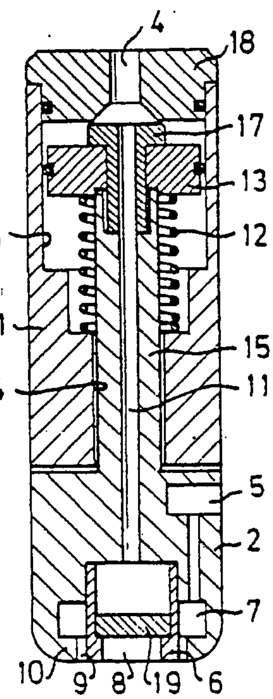


FIG. 2

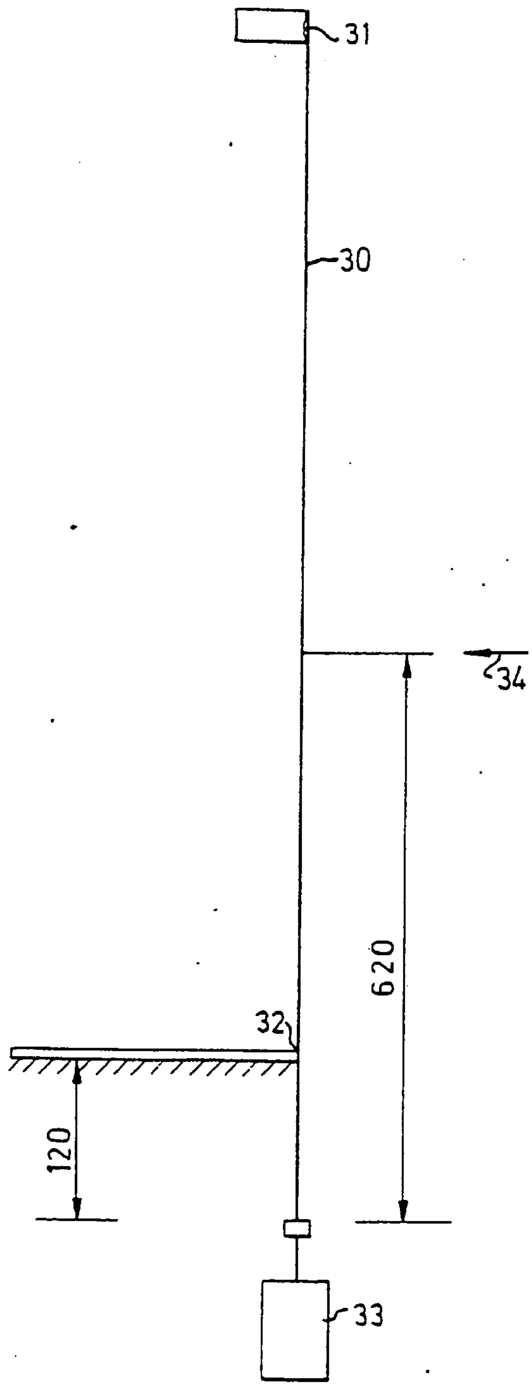
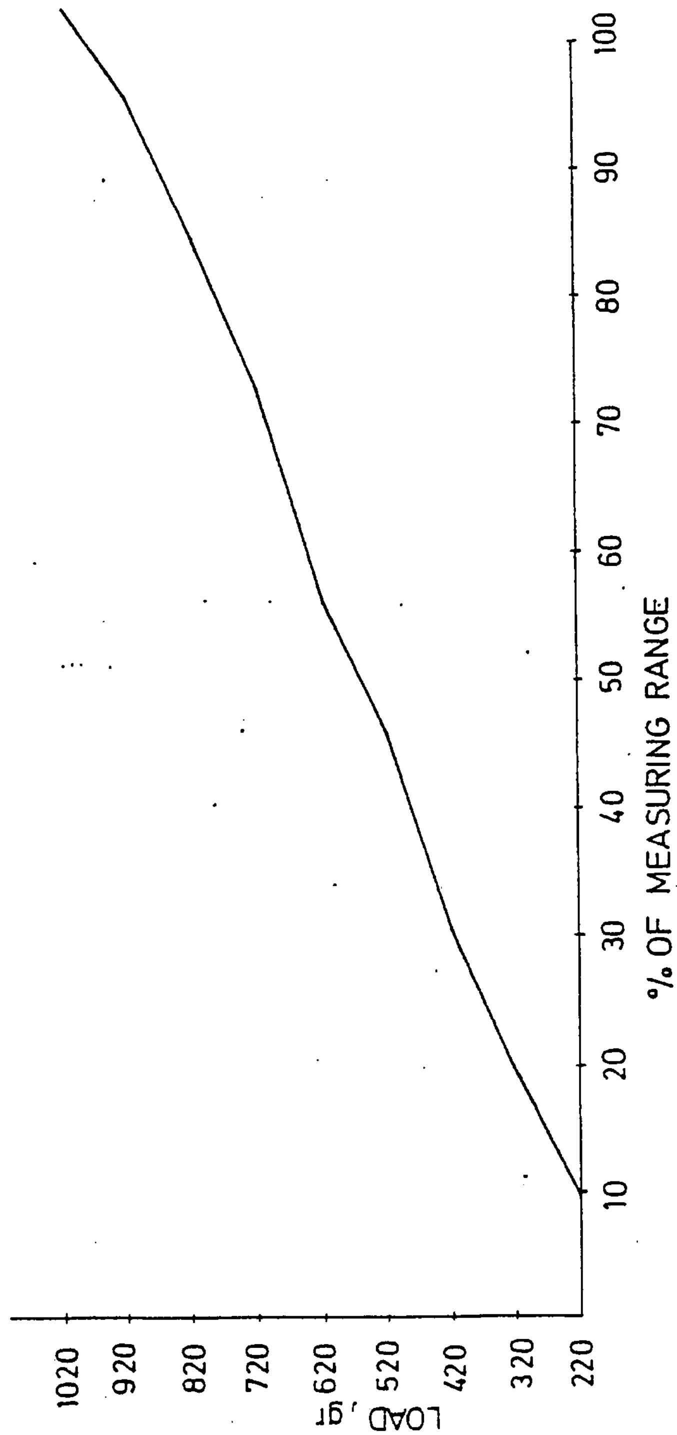


FIG. 3



LOAD, gr
1020
920
820
720
620
520
420
320
220
% OF MEASURING RANGE
10
20
30
40
50
60
70
80
90
100

FIG. 4

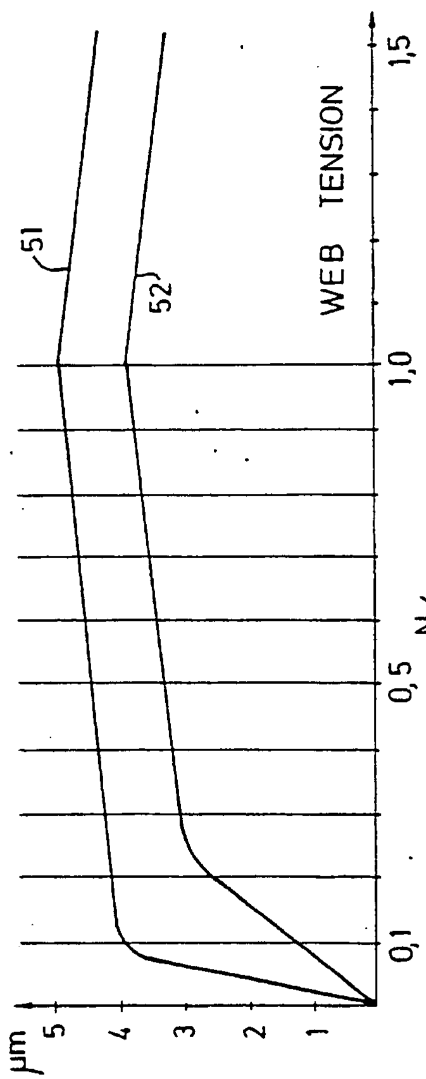


FIG. 5

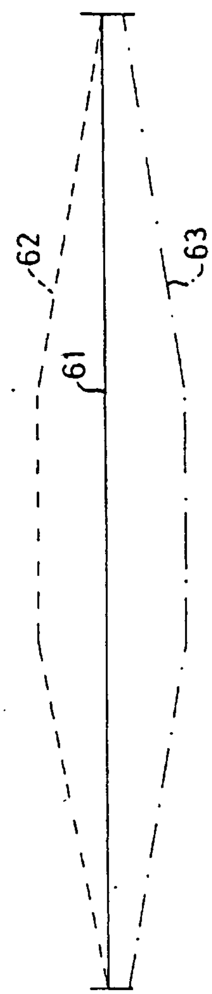


FIG. 6